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Simulation Analysis of Temperature Field in the Heat Transfer Process of Shell

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Abstract

Sea temperature is the key factors that determines whether shellfish can maintain normal growth development and survival, as protective film, the shell is a very important part of structure of shellfish, so the research of heat transfer characteristics become very important. In this paper, we firstly make a comprehensive analysis on the appearance of the shell, for the next simulation builds a good foundation, and based on the large general finite element analysis software ANSYS, we analyze the thermodynamics of shells, study the effect of the shell thickness and structure on heat transfer time. And through apply different temperature load, analyze the heat transfer characteristics and temperature distribution of the shells, It is expected that the results is useful at the biological heat transfer of shellfish.

Keywords: Shells, Heat transfer, Temperature field, Simulation analysis, ANSYS;

1. Introduction

Shellfish, belong to the Mollusca, Bivalvia, since the 1980 s, domestic scholars have made many research on its shape structure, reproductive biology, ecological habits and so on [1]. In recent years, the research of the relationship between the salinity and temperature of sea and the growth and survival of shellfish has had many reports, as we all known, the water temperature is the key factor in the survival of shellfish, according to the previous literature, it is known that the sea temperatures range is minus 2 ℃ to 30 ℃, and shellfish can grow very well within the range of temperature is from 3 ℃ to 25 ℃ [2], Shell is

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the coat film of software animal, the main composition is calcium carbonate, study the heat transfer characteristics of shells can be very good to help us to further explore that the influence of temperature on shellfish growth.

ANSYS software which combines the structure, fluid, electric field, magnetic field, sound field analysis, is large general finite element analysis software [3]. This paper is mainly use ANSYS thermal analysis function, in order to calculate the temperature distribution of shell internal, experiments use different external conditions independently, to analyze the heat transfer process of shell internal in different times and different temperature, and therefore get the heat transfer characteristics and temperature field characteristics of shells which has the particular shape, help us lay a good foundation for the following experiment research.

2. Shell Temperature Field Simulation

2.1. The basic principle of thermal analysis

The temperature distribution of object interior depends on the heat exchange of object interior, and the heat exchange between object and external medium, it's generally associated with time [4]. We should consider the calculation of shell temperature field on the two-dimensional transient temperature field; the transient temperature field should meet the following heat conduction differential equation and the corresponding initial condition and boundary conditions [5].

First we should set that material is isotropic, the thermal conductivity is identical on the different direction, so, the heat conduction equations as shown in formula 1.

$$\rho c \frac{\partial T}{\partial t} = \lambda \frac{\partial^2 T}{\partial x^2} + \lambda \frac{\partial^2 T}{\partial y^2} + \overline{Q} \qquad (1)$$

There: T is the surface temperature of the shell; C is specific heat; ρ is density.

Initial conditions [6]: T（x，y，0）=T0（x，y），t=0

We set that the temperature brought to bear on shell outside is a constant value, so temperature T on the outside of shell is the known function of time, so the boundary conditions is first class boundary conditions: T（τ）=f（τ）.

2.2. The finite element analysis model of temperature field

In this paper, the research object is shell, so prior to in modeling, we should make a preliminary analysis on the morphology of shell. First of all, place shell flat, its plan view is a basic elliptic, and set the long axis direction for the X axis, short axis direction for the Y axis, measure the length of the shaft length roughly, the results are 60 mm and 40 mm respectively; and then take some key points in the oval range, and measure the height and thickness of these key points respectively, thus draw the contour map and thickness chart of shell, As shown in figure 1 and figure 2.

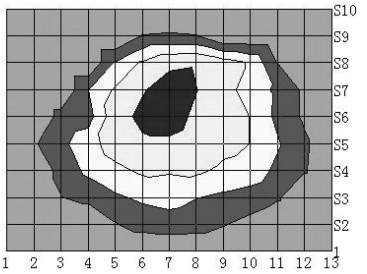

Fig1 contour map of shell

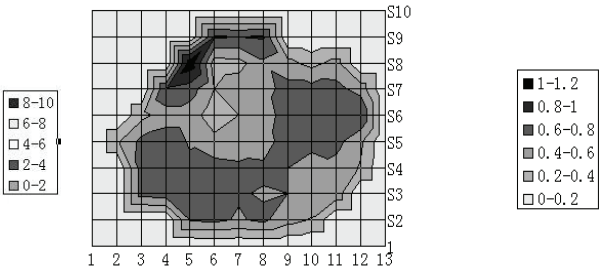

Fig2 thickness chart of shell

Shells play an important role in protecting its internal software organizations. So it has only study the part which contact with software organizations in this thesis, as the area of dashed internal in Fig.3. By the means of Fig.1 and Fig.2, the topography characteristics of this part is high and thin in the middle but low and thick in the border. So, it can choose the section along the Y direction to analysis in this part. According to the topography Characteristics, the shape of the section can be showed by Fig.4, precisely bow graphics composed by two different circular arcs with different radius and center. Then, according to the actual thickness of the shell, it can set two circular arcs with radius of 25mm and 30.5mm, the distance between the centers is 5mm.

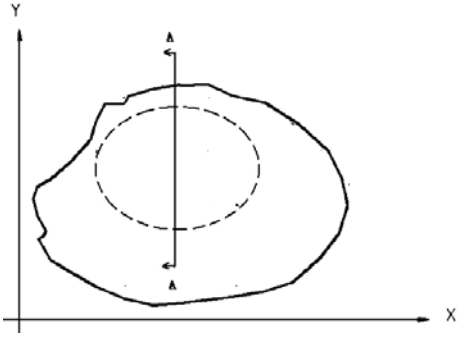

Fig3 Regional classification sketch map

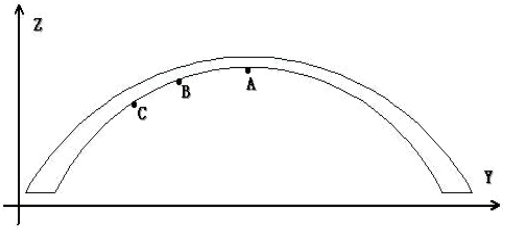

Fig4 Section sketch map of shell

The main heat transfer method of shell is heat conduction, choose two-dimensional temperature element solid55 for modeling, and define the corresponding materials performance parameters, the parameters as shown in table 1. The mesh as shown in figure 5. According to the temperature range of shell survival and the sea temperature range, this paper select the temperature brought to bear on shell outside are 10 ℃, 20 ℃ and 30 ℃ respectively, the initial temperature of shell internal is 0 ℃.

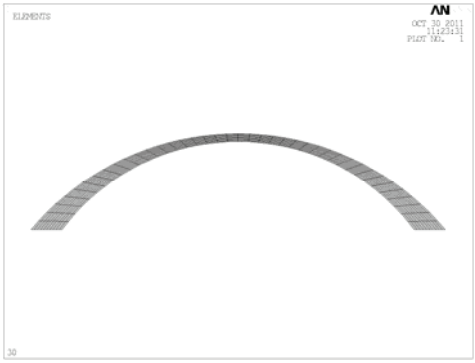

Fig 5 the mesh of model

Table 1 materials performance parameters

performance parameters	numerical value
Density Kg/m3	2729
Thermal conductivity W/(m·℃)	0.1734
Specific heat J/（Kg·℃）	878

3. Calculation result analysis

3.1. Heat transfer trend of shells internal

When the applying temperature is 30℃, the heat conduction situation of shell internal region as shown in Figure 6. The time corresponding to figure 6A-F is 120S, 600S, 1200S, 1800S, 3600S, 7200S respectively, it can be seen that, when the temperature is loaded uniformly on the shell outside, the top region which is thinner can firstly finish the heat transfer, on the face of it, this phenomenon is only connected with distance of heat transfer, but through the careful observation and comparison, it can be seen that the finish time for heat transfer in different thickness areas is not completely linear relationship to the thickness of these areas. Through the analysis, it can be concluded that, in this bow structure, it easier for the top thinner area to concentrate heat, thus leading to the speeding up of the heat transfer. The results will also be reflected in following analysis.

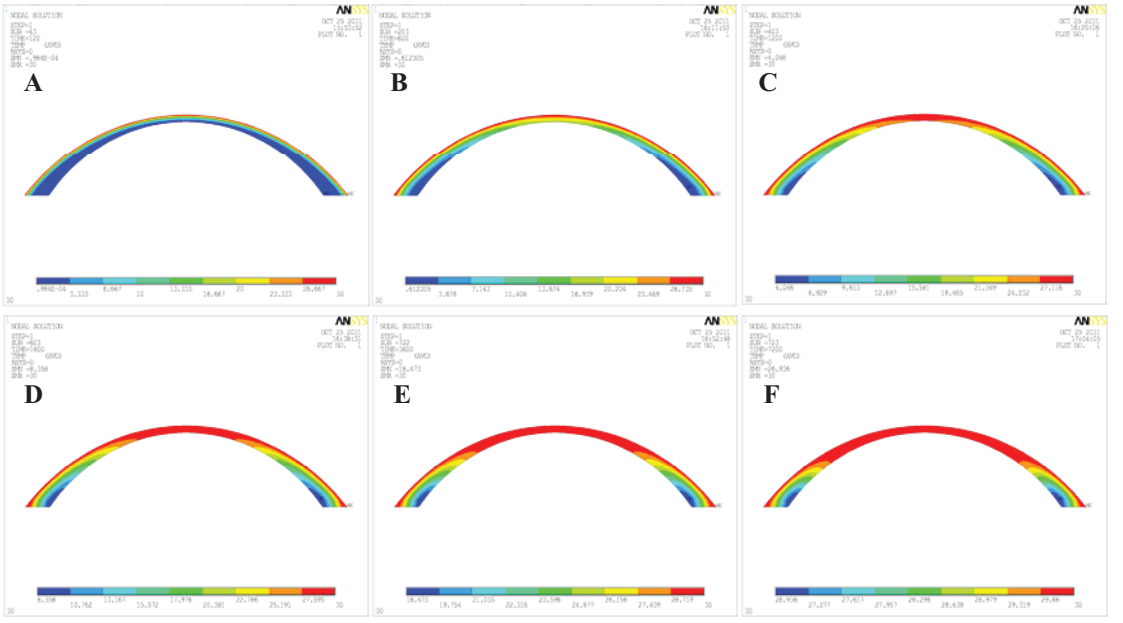

Fig6 simulated result A-120S B-600S C-1200S D-1800S E-3600S F-7200S

3.2. The relationship of thickness and heat transfer time

As shown in figure 4, select three special points (A, B and C) in the shell inside, and after measurements, the thickness of three points are 0.26mm, 0.53mm and 0.79mm, the ratio of thickness is about 1:2:3. When the applying temperature is 30 ℃, calculate the temperature of three points respectively in all time points, the whole time is 7200S, time interval is 600S. The figure 7 shows the temperature—time curve of three points.

It can be seen from the graph that the temperature of each point rising along with the advancement of time. And the speed of temperature rise gradually becomes slower. The variation rate of curve A is the fast, and curve B takes second place. Curve C is the slowest. The times when the two points of A, B get to 30℃ are 1800s, 4800s. But point C has not finished heat-transfer process at 7200s. It is thus clear that, the ratio of finish time for heat-transfer is less than the ratio of thickness at point A, B, C. So, it has proved that thin area is much easier to transfer heat once again. In addition, between 0s to 1200s,the temperature of the shell remain less than 25℃. And this temperature is suitable for the growth and development of shellfish. Therefore, if the Sea temperature constant for 30℃, it will not affect the normal growth and development of the shellfish within 20 minutes.

3.3. The relationship of temperature and heat transfer time

In order to analyze the influence of temperature on heat transfer time, it will be used respectively 30 ℃, 20 ℃, and 10 ℃ as applied loadings of temperature field simulation, and only observe the temperature change situation of point A. Calculate the temperature of different temperature respectively in all time points, the whole time is 1800S, time interval is 240S. The figure 8 shows the temperature—time curve of three different applying temperatures.

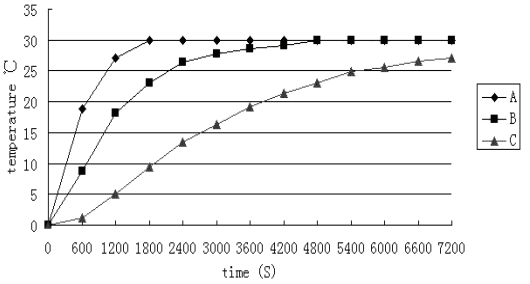

Fig 7 the temperature—time curve of three points

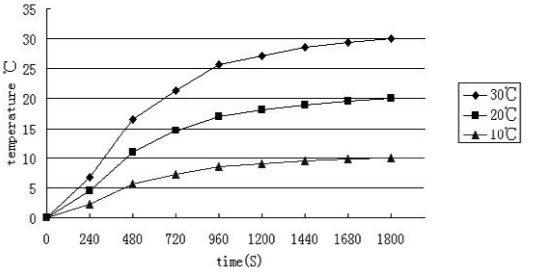

Fig 8 the temperature—time curve for different applying temperature

It can be seen from the graph, as time go on, the temperature of point A are gradually raised, the change rule of three curves is completely consistent, and they all finish the heat conduction in 1800S. Through careful observation and computing, it still can see, the ratio of three applying temperature is 3:2:1, and in every time points, the ratio value of temperature of point A on three curves is 3:2:1, this value is same to the ratio of three applying temperatures which loaded in the beginning, so, it is proved that the size of the temperature load will not affect heat transfer speed; and that, under different temperature load, the temperature distribution are same inside the shell at the same time.

4. Conclusion

1. In this shell bow structure, it easier for the top thinner area to concentrate heat, thus leading to the speeding up of the heat transfer.

2. In the heat transfer process of shell, the ratio of finish time for heat-transfer is less than the ratio of thickness.

3. The size of the temperature load will not affect heat transfer speed; and that, under different temperature load, the temperature distribution are same inside the shell at the same time.

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